

CLAIMS

1 1. A method for growing a thin tungsten silicide film on a substrate in a
2 reaction space, comprising:

3 (a) providing a hydrated substrate;

4 (b) introducing a tungsten halide precursor, where the halide is not fluorine,
5 into the reaction space to the hydrated substrate to create, for example, a chlorine
6 terminated substrate surface and deposit tungsten without scavenging silicon;

7 (c) introducing a silicon hydride precursor into the reaction space to the
8 chloride terminated substrate surface to create a hydride terminated substrate surface
9 and deposit silicon;

10 (d) repeating steps (b) and (c) an integral number of times to form a tungsten
11 silicide film on the substrate, wherein a reaction by-product is a hydrogen halide.

1 2. The method of claim 1, wherein the temperature of the reaction space
2 is maintained less than 600 °C.

1 3. The method of claim 1, further comprising:
2 providing an inert purge after each (b) and (c) step.

1 4. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

3 (a) providing a hydrated substrate;

4 (b) introducing a tungsten halide precursor, where the halide is not fluorine,
5 into the reaction space to the hydrated substrate to create a halide terminated
6 substrate surface;

7 (c) introducing a silicon precursor selected from $\text{Si}_n\text{X}_m\text{Y}_k\text{H}_l$, where X and Y
8 are halides and n,m,k,l are integers, into the reaction space to the halide terminated
9 substrate surface to create a hydride terminated substrate surface;

10 (d) repeating steps (b) and (c) an integral number of times to form a metal
11 silicide film on the substrate, wherein a reaction by-product is a hydrogen halide.

1 5. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

3 (a) providing a hydrated substrate;

4 (b) introducing a tungsten halide precursor, where the halide is not a fluorine,
5 into the reaction space to the hydrated substrate to create a halide terminated
6 substrate surface;

7 (c) introducing silicon precursor selected from $\text{Si}_n\text{X}_m\text{Y}_k\text{H}_l$, where X and Y
8 are halides, and n,m,k,l are integers, into the reaction space to the halide terminated
9 substrate surface to create a hydride terminated substrate surface;

10 (d) introducing atomic hydrogen into the reaction space to create a hydrogen
11 terminated substrate;

12 (d) repeating steps (b), (c) and (d) an integral number of times to form a
13 metal silicide film on the substrate, wherein a reaction by-product is a hydrogen
14 halide.

1 6. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

3 (a) providing a hydrated substrate;

4 (b) introducing a tungsten halide, where the halide is not fluorine, into the
5 reaction space to the hydrated substrate to create a halide terminated substrate
6 surface;

7 (c) introducing atomic hydrogen into the reaction space to the surface
8 previously terminates with a halide

9 (d) introducing a silicon chloride precursor into the reaction space to the
10 surface previously terminated with a halide; and

11 (e) repeating steps (c), (b), (c) and (d) an integral number of times to form a
12 metal silicide film on the substrate, wherein a reaction by-product is a hydrogen
13 halide.

1 7. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

- 3 (a) providing a hydrated substrate;
- 4 (b) introducing a tungsten halide, where the halide is not fluorine, into
5 the reaction space to the hydrated substrate to create a halide
6 terminated substrate surface;
- 7 (c) introducing atomic hydrogen into the reaction space to the surface
8 previously terminated with a halide to create a hydrided surface;
- 9 (d) introducing a silicon chloride precursor into the reaction space to the
10 hydrogen terminated substrate surface to create a halide terminated
11 substrate surface;
- 12 (e) introducing atomic hydrogen into the reaction space to the surface
13 previously terminated with a halide; and
- 14 (f) repeating steps (b), (c,) (d), and (e) an integral number of times to
15 form a metal silicide film on the substrate, wherein a reaction by-
16 product is a hydrogen halide.

1 8. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

- 3 (a) providing a hydrated substrate;
- 4 (b) introducing a first tungsten halide, where the halide is not fluorine, into
5 the reaction space to the hydrated substrate to create a halide terminated substrate
6 surface;

7 (c) introducing atomic hydrogen into the reaction space to the surface
8 previously terminated with a halide;

9 (d) introducing a second tungsten halide, where the halide is not fluorine,
10 into the reaction space to the hydrated substrate to create a halide terminated
11 substrate surface;

12 (e) repeating steps (c) and (d) an integral number of times

13 (d) introducing a silicon hydride into the reaction space to the surface
14 previously terminates with a halide; and

15 (e) repeating steps (b), (c) and (d) an integral number of times.

1 9. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

3 (a) providing a hydrated substrate;

4 (b) introducing a tungsten halide precursor, where the halide is not fluorine,
5 into the reaction space to the hydrated substrate to create a halide terminated
6 substrate surface;

7 (c) introducing Si hydride into the reaction space to the surface previously
8 terminated with a halide;

9 (d) introducing Si halide into the reaction space to the surface previously
10 terminates with a hydride;

11 (e) repeating (c) and (d) an integral number of times

12 (f) introducing Si hydride into the reaction space to the surface previously
13 terminated with a halide; and

14 (g) repeating steps (b) through (f) an integral of number of times.

1 10. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

- 3 (a) providing a hydrated substrate;
- 4 (b) controllably depositing a metal silicide with an ALD process in a pre-
- 5 determined number of ALD cycles to form a metal layer on the hydrated substrate;
- 6 (c) terminating the metal layer with a halide to form a surface halided metal
- 7 layer;
- 8 (d) controllably depositing a tungsten layer using WCl_6 ALD chemistry with
- 9 H reduction;
- 10 (e) repeating steps (b) (c) and (d) an integral number of times to form a
- 11 nanolaminate of silicide and metal layers on the hydrated substrate.

1 11. A method for growing a thin film on a substrate in a reaction space,

2 comprising:

- 3 (a) providing a hydrated substrate;
- 4 (b) controllably depositing a metal silicide with an ALD process in a pre-
- 5 determined number of ALD cycles to form a metal layer on the hydrated substrate;
- 6 (c) terminating the metal layer with a halide to form a surface halided metal
- 7 layer;
- 8 (d) controllably depositing additional tungsten layers using WF_6 ALD
- 9 chemistry with silicon hydride reduction; and
- 10 (e) repeating steps (b) (c) and (d) an integral number of times to form a
- 11 nanolaminate of silicide and metal layers on the hydrated substrate.

1 12. A method for growing a thin film on a substrate in a reaction space,

2 comprising:

- 3 (a) providing a hydrated substrate;
- 4 (b) controllably depositing a metal halide with an ALD process in a pre-
- 5 determined number of ALD cycles to form a metal layer on the hydrated substrate;

6 (c) introducing atomic hydrogen into the reaction space to the surface
7 previously terminated with a halide to create a hydrided surface;
8 (d) controllably depositing silicon halide; and
9 (e) repeating steps (b) (c) and (d) an integral number of times to form a
10 nanolaminate of silicide and metal layers on the hydrated substrate.

1 13. A method for growing a thin film on a substrate in a reaction space,
2 comprising:

3 (a) providing a hydrated substrate;
4 (b) controllably depositing a metal halide with an ALD process in a pre-
5 determined number of ALD cycles to form a metal layer on the hydrated substrate;
6 (c) introducing atomic hydrogen into the reaction space;
7 (c) introducing a silicon halide into the reaction space;
8 (d) introducing atomic hydrogen into the reaction space; and
9 (e) repeating steps (b) (c). (d) and (e) an integral number of times to form a
10 nanolaminate of silicide and metal layers on the hydrated substrate.